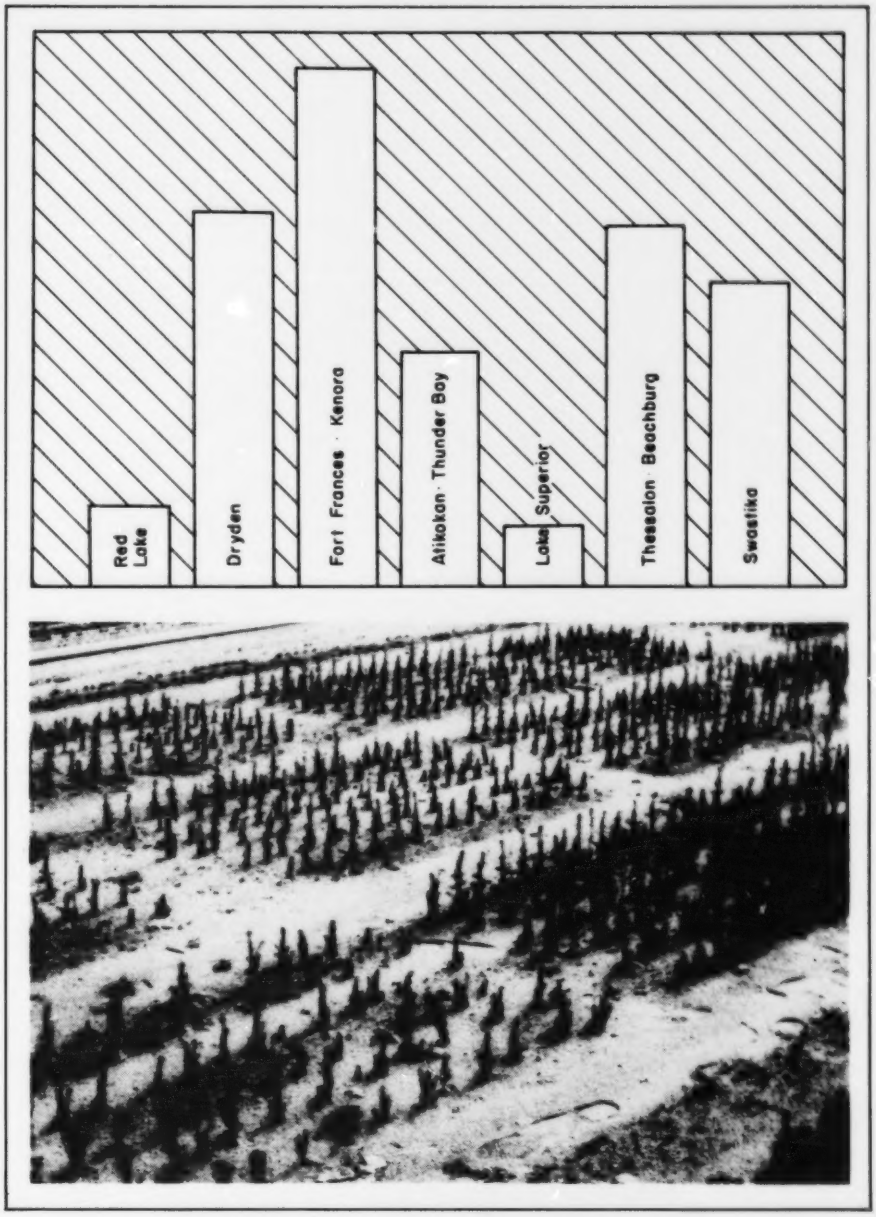
Forest Research Report No. 122

Nursery Indications of White Spruce Provenance Variability in Northwestern Ontario



Ministry of Natural Resources
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Cover Illustrations:

Bar graph (top) illustrates relative differences in stock mean heights of sources grouped according to geography and performance. Such variation between trees of different sources (bottom) was apparent in nursery plots as early as one-year transplants.

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Abstract

Collections of white spruce seed were made from stands across northwestern Ontario. Provenance trials were initiated including sources primarily from Manitoba, north central Ontario, and eastern Ontario. Container stock for three experiments was transplanted into Dryden Nursery.

On the basis of three years' height growth in the nursery, data has been grouped into three areas of northwestern Ontario. These approximate current seed zones, with minor differences. Groupings of other Ontario sources cross seed zone boundaries.

Seed management policy is discussed in light of these early results at Dryden. Selection of registered stands and a system of point source identification of seed lots are recommended as a basis for seed collection. It is further recommended that distribution beyond the current framework of site regions and administrative districts and regions be limited to study areas. Concern is expressed for the potential influence of ecotypic variation within seed zones and managers are urged to match seed collection strategies to the sites being regenerated.

Introduction

At a joint federal-provincial tree improvement symposium, the keynote speaker, Gilles Vallee (1979), expressed the need for expanded provenance testing with more intensive sampling to develop our knowledge of growth potential of Canadian forest tree species. In early white spruce [Picea glauca (Moench) Voss] provenance trials in Ontario (Teich et al. 1975), sampling was largely limited to the Great Lakes/St. Lawrence Forest Region with scattered representation from eastern boreal regions of northern Ontario (Rowe 1972). Considerable variation in plantation performance was attributed to seed source. In the Thunder Bay and Fort Frances experiments, the only two western sources exhibited average or below average performance relative to faster growing sources from eastern and southern Ontario.

The magnitude of variation in past studies suggested the high probability of gains in growth through selection and testing of seed sources for artificial regeneration programs. More intensive sampling was initiated in 1971 as a basis for regional and all-range white spruce provenance trials across Ontario. The first series covered northwestern Ontario for which little previous information existed. The purposes of the study were (1) to determine the magnitude of growth variation among northwestern Ontario sources, (2) to delineate geographic areas based on groupings of seed sources of comparable growth potential and (3) to establish effective seed transfer rules. The ultimate goal is to achieve more vigorous plantations.

This paper is a preliminary assessment of vigour based on performance of plants from 75 sources after three years of growth in transplant beds in Dryden nursery. On the basis of this assessment, related subjects such as zonation, seed collection, seed distribution, ecotypic variation and implications for management are discussed.

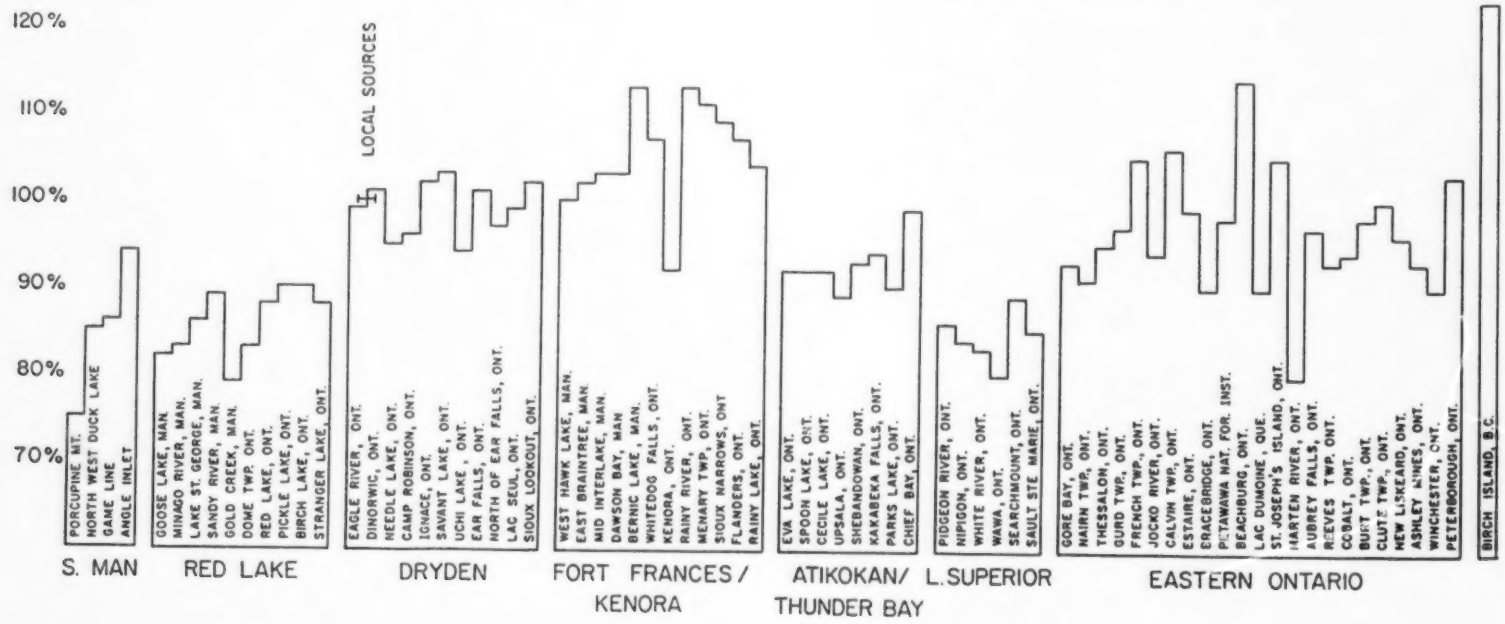
Materials and Methods

Stands of white spruce across northwestern Ontario were selected and collections made during a moderate seed year in 1971 and a good seed year in 1973. Sampling was based on a minimum of two sources per site district within site regions (Hills 1960). Stands selected were considered average or above average within the site district. In most stands ten trees were sampled although some collections consisted of as few as five or six trees. A few sources from past trials were included as well as seed lots from other provinces, especially from Manitoba.

Seed from each tree was extracted and equal quantities of seed from individual trees of each collection were mixed to provide a representative sample for the stand. Seed was sown in Ontario tubes at the Ontario Tree

FIGURE 1

NORTH WESTERN ONTARIO – WHITE SPRUCE PROVENANCES
DRYDEN NURSERY



Improvement and Forest Biomass Institute in June 1974, 20 tubes being sown for each of 80 sources. Five replications were established in each of three experiments for outplanting in Fort Frances, Kenora and Red Lake Districts. Greenhouse problems resulted in considerable loss of stock and reduced early growth of surviving trees. One of the 15 replications was utilized to fill gaps in the other 14.

Seedlings were transplanted by hand in Dryden nursery in the summer of 1975. The greenhouse experimental design, ie. 14 randomized blocks of 80 sources, was maintained in transplant beds. A second transplanting was necessitated because of nursery activities prior to the third year's growth of trees for the study.

Heights of all seedlings were measured and subjected to analysis of variance using a randomized block program (Snedecor and Cochran 1967). Due to losses in the nursery, five of the 80 sources were excluded from the analysis and a missing value routine was employed to compensate for sources inadequately represented in some replications. Sources were grouped according to comparable mean heights within geographic locations. Adjacent groups were compared by t-tests (Freese 1967).

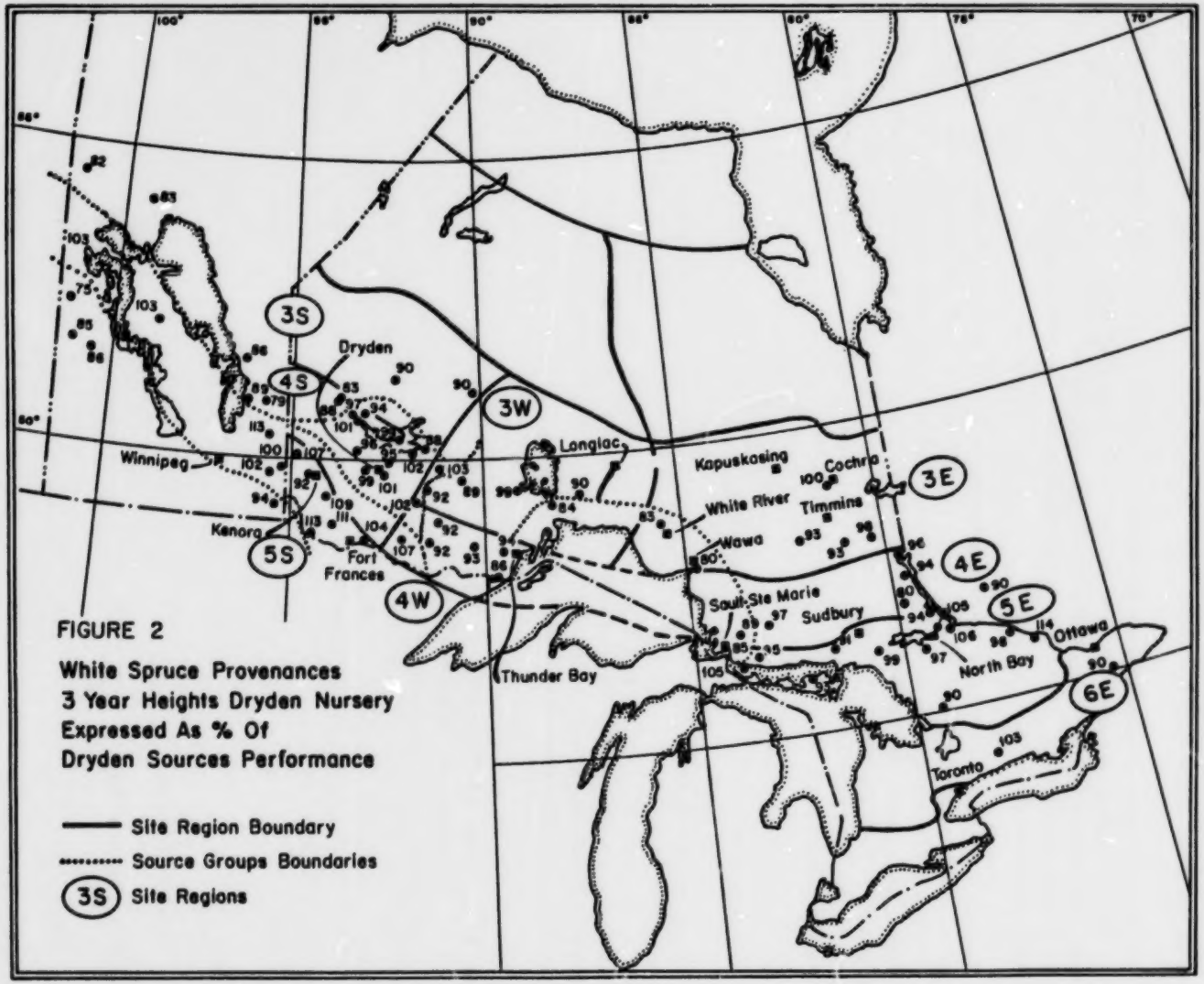
Results

Mean three-year nursery heights were determined for trees of each source (Appendix 1). Height of local stock, determined by averaging mean heights of Dinorwic and Eagle River plants, was 28 cm. The most vigorous transplants in the study were those from seed from Birch Island, B.C. Analysis of variance indicated highly significant differences in mean height between sources in the trial ($p=.01$).

Table 1. t-test comparisons of group means based on averages of mean heights per source (Freese 1967).

	# Sources	Mean Ht. (cm)	Standard Deviation (cm)	t_{05}
Red Lake	10	24.06	1.09	
				**
Dryden	11	27.77	0.89	
				**
Fort Frances/Kenora	12	29.59	1.74	
				**
Atikokan/Thunder Bay	8	26.00	0.86	
				**
Lake Superior	6	23.79	0.86	
				**
Thessalon/Beachburg	17	27.57	2.03	
				**
Swastika	6	26.88	0.76	
				NS

** Indicates values significantly different at the 95% confidence level.


3S
4S
5S
3W
4W
3E
4E
5E
6E
Dryden
Winnipeg
Kenora
Fort Frances
Langlac
Kapuskasing
Cochrane
White River
Timmins
Wawa
Sault Ste Marie
Sudbury
Thunder Bay
North Bay
Ottawa
Toronto
FIGURE 2
White Spruce Provenances
3 Year Heights Dryden Nursery
Expressed As % Of
Dryden Sources Performance
Site Region Boundary
Source Groups Boundaries
3S Site Regions

All mean heights were converted to percentages of local mean height, ie. 28 cm being 100%. Based on similar performance within geographic locations, sources were grouped as indicated in a bar graph (Fig. 1). Using t-test analyses, adjacent groups were found to be significantly different from one another (Table 1), except between northern and southern groups of sources in eastern Ontario which are therefore considered as a single group in Figure 1. For Ontario and Manitoba sources, percentages are plotted in Figure 2 at point of seed origin.

Performance of trees of sources within groups are described below. The most vigorous transplants in the nursery, ie. those from Birch Island in the interior of southern B.C., were from seed of a source which does not fit geographically with any of the groups.

Dryden

Stock from seed lots collected around Lac Seul, westward to Ear Falls and eastward to Ignace exhibited similar vigour ranging from 95% to 103% of local mean height. Sources close to Lac Seul, to the north of Dryden nursery, tended to produce more vigorous stock than those farther away from the lake.

Red Lake

The seed sources farther to the north and west of the Dryden group were found to produce less vigorous transplants than did local Dryden sources. This group included collections from Pickle Lake in the east to sources east and northwest of Lake Winnipeg in Manitoba. Values ranged from 79% to 90% of local mean height.

Fort Frances/Kenora

Twelve sources to the south and west of Dryden exhibited superior performance compared to those of Dryden. The area covered ranged from Flanders in the Atikokan District to the Lake of the Woods, northerly to Kenora and Whitedog Falls and westerly between Lake Winnipeg and Lake Winnipegosis. Values ranged from 100% to 113% of local mean height, with Pellatt Twp. near Kenora being an exception (92%). Stock from some of these sources was among the most vigorous relative to that of other Ontario collections.

Atikokan/Thunder Bay

Trees from sources east of Ignace and Atikokan generally exhibited lower vigour than those from either the Fort Frances/Kenora or Dryden groups. Compared with Dryden mean height, the eight sources in this group ranged from 90-94% for sources in Ignace, Atikokan, southern parts of Thunder Bay and Parks Lake in Nipigon Districts to 99% for Chief Bay near Lake Nipigon.

Lake Superior

Six sources from stands around the west, north and east shores of Lake Superior exhibited similar performance. Sources included were from Pidgeon River near the Minnesota border, around the lake, through Nipigon, Wawa, and White River, to Sault Ste. Marie. Mean heights varied from 80-86% of those from Dryden.

Eastern Ontario

Twenty-three sources from eastern Ontario exhibited considerable variation in mean transplant heights but few distinguishable patterns. Transplants from central Ontario sources west of Lake Nipissing and south through Parry Sound, tended to be 5-10% shorter than Dryden transplants.

Lower Ottawa Valley sources varied inconsistently from Winchester in the south-east (90%) to Beachburg near Pembroke, the tallest Ontario source in the trial (114%). Two sources near Mattawa, Calvin Twp. (106%) and French Twp. (105%) were taller than the Dryden trees, but others, ie. Jocko Twp. (94%) and Martin River (80%), were less vigorous. More northerly sources near Lake Temiskaming were shorter than Dryden trees (94-96%) while those from Burt Twp. near Kirkland Lake (98%) and Clute Twp. (100%) exhibited vigour comparable to Dryden trees.

Southern Manitoba

Four sources in Manitoba, west of the Lake of the Woods and lake Winnipegosis toward the Saskatchewan border, appeared to be distinctly less vigorous than sources farther east in Manitoba and northwestern Ontario.

Discussion and Recommendations

Decisions at each step in the silvicultural continuum, from selecting seed sources to be collected, through stock production to stock distribution for each planting site, have an effect on plantation performance. Variability in white spruce nursery stock has been shown to affect height and increment ten years after planting (Mullin and Svaton 1972). Data presented here indicates that the choice of seed source is an important factor influencing stock quality. Differences were expressed despite stresses due to disturbances in the greenhouse, hardening off, transplanting and a second transplanting prior to lifting for outplanting.

Performance of trees of different origins in older Ontario trials has been shown to be highly correlated with early plantation data (Murray and Skeates 1985). Unpublished data from these trials indicate that the statistical significance of differences due to seed source is maintained or increases with time. The genetic potential of our future forests is established at the time of seed collection. Distribution of source-identified seed is the first decision to be made in determining to what extent that potential will be achieved.

Zonation

Current seed policy in Ontario is based on a system of ecological site regions described by Hills (1960). This was modified to allow identification of collections by administrative districts and regions, as well as site regions (Skeates 1979). Subsequently, changes have been made in numbering systems within this collection and distribution framework.*

With two notable exceptions, the data from this study tends to support the validity of the three ecological site regions of subhumid Ontario as seed zones. In the first exception, height growth of plants from Red Lake sources (83-88%) was less than that from Ear Falls sources (94-101%), 50 km to the south, both in site region 4S. This would suggest a possible population difference occurring somewhat south of the 3S/4S site region boundary on the western side of the region (Fig. 2). Secondly, a population change is indicated about Atikokan in the south and Ignace on Highway 17. This is slightly different from the boundary between western and sub-humid site regions delineated by Hills (1960).

Sources from within seed zones of the western and eastern site regions did not relate as closely to ecological zones. Based on comparable performance of sources around Lake Superior, a group was delineated including Pidgeon River (86%) near the U.S. border, through Nipigon (84%), White River (83%) and Wawa (80%) to Searchmont (89%) and Sault Ste. Marie (85%). This group crosses five site regions.

Delineation of eastern seed sources based on performance is not as apparent. As previously noted trees of Beachburg (114%) and two Mattawa sources, Calvin Twp. (106%) and French Twp. (105%), exceeded values of Dryden trees. However, other sources from eastern site regions were generally less vigorous, whether from region 3E in the north, 6E in the south or from more westerly sources in 5E. It is expected that additional studies under way in eastern site regions will clarify the variation in population indicated in the Dryden nursery results.

Should similar patterns become apparent in other nursery trials and outplanting experiments, the subject of seed zonation may need to be reviewed.

Seed collection control

Past studies have indicated the value of Beachburg and Cobourg sources of white spruce seed (Nienstaedt and Teich 1972). Provenance studies will eventually be used to delineate population boundaries which might be used as collection zones. The groups delineated in Appendix 1, except for the large area of eastern Ontario, appear to indicate zones from which similar performance might be expected from various seed sources. However, stand to

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* OMNR Forest Resources Policy & Procedure Directives. Procedure No. FR 11 01 10. Tree Seed Identification.

stand differences in performance of white spruce nursery stock within the group suggests the value of an alternative to zonation, the maintenance of discreet seed source identity by stand or limited geographic area, from time of collection until forest establishment.

Seed distribution

Nursery results of this trial show the influence of seed transfer to Dryden from many locations. Stock of local sources performed well in the nursery while all sources within the Dryden group produced stock within +/- 5% of the heights of trees from local collections.

Seed of some sources farther removed from Dryden produced stock which outperformed that of Dryden sources. Most notable are the sources from the south and west, some of which were 5-13% taller after three years in the nursery. These are well within the two degrees of latitude recommended by Morgenstern and Roche (1969) as being a safe limit of seed transfer.

Farther removed are sources from the lower Ottawa Valley. Most notable in this trial is the Beachburg source which produced marginally taller trees than did Rainy River stock from the Lake of the Woods area. Long term studies in the Lake States have indicated the positive value of long range seed transfer of eastern Ontario sources to the planting programs of those states (Nienstaedt and Teich 1972).

However, long range seed transfer should not be encouraged until adequate outplanting trial results indicate the benefits of such a move.

Ecotypic variation

Limestone and granitic ecotypes have been identified in southern Ontario (Teich and Holst 1974). Data presented here is not based on site identification, however it appears likely that some of the differences in performance of nursery stock of various origins may be due to this factor. Stand (or population) source identification of collections, including site/soil descriptions, would allow the forest manager to match stock origin to plantation site conditions with a probability of improved plantation performance. By matching broad categories of soil type at point of seed origin to planting site at least the probability of poor performance should be reduced.

Management application

Results of this study are primarily applicable to the Dryden Forest District. However, staff of other districts should consider the differences in stock performance among sources from their districts. Stock of seed from Rainy River (113%) and Menary Twp. (111%) were outstanding in the trial compared to more easterly sources in the Fort Frances District. Sioux Narrows stock (109%) from stands near Lake of the Woods, and stock of Whitedog Falls (107%) outperformed more easterly sources in the Kenora District. Bernic Lake seed (113%) from west of the Manitoba/Kenora boundary produced some of the tallest stock in the trial.

In the Red Lake District, seed of Ear Falls sources produced taller stock than did seed of Red Lake sources. Seed of Ear Falls origin (101%) produced the most vigorous stock of sources from within the Red Lake District. In the Sioux Lookout District, the Sioux Lookout source (102%) produced more vigorous stock than other sources in the district, especially those farther to the north of Lac Seul.

Ignace and Atikokan appeared to be on a dividing line between two groups. Savant Lake (103%) and Ignace (102%) might represent suitable locations to concentrate seed collection in the Ignace District. Flanders stock (107%) was more vigorous than more easterly sources in the Atikokan District.

Until seed orchard production meets seed requirements it would be worthwhile for districts with significant white spruce planting programs to select and develop seed production areas. The above early results may provide suitable guidelines for such selection. Local stand tests for this species are also warranted to evaluate district seed sources and provide information for other tree improvement programs.

Provenance information provides an important foundation for subsequent breeding strategies. Plus tree selection effort should be concentrated in stands within populations which have been shown to produce progeny with increased vigour. No doubt future breeding programs for a given breeding zone will include plus trees from a number of stands. The identification of population differences should facilitate selection of genetic material to be used in such programs.

Conclusions

Results from provenance trials at the nursery stage provide preliminary information on performance of sources in that vicinity. It is expected that data from Dryden nursery would provide relevant information for sources within site region 4S. Sources from much farther afield, and from very different eco-climatic regions, ie. Birch Island, B.C., though promising in terms of nursery data, may not maintain superiority for the long run in plantations. Greater differentiation between sources would be expected once plants grow above winter snow depths.

Beachburg and Cobourg have proven to be superior sources of seed in terms of plantation performance in many areas of Canada and northern U.S. Though both have grown well at Dryden, seed of some northwestern Ontario and Manitoba sources showed equal vigour and are to be preferred at this time.

This preliminary data supports the selection, utilization and testing of seed production areas in each district. Such seed sources represent a sounder investment base than general collections during the years before seed orchards come into production. They also ensure population source identity of seed, the lowest standard of seed quality recognized internationally (Piesch and Stevenson 1976). Designation of specific

populations as seed production areas also serves to establish identified and evaluated genetic resources that can readily be managed to maintain samples of original gene pools in perpetuity (Yeatman 1973).

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Appendix 1

	Height cm	SE	% of Local (L)	Lat.	Long.	Elev. (m)	GDD*
Red Lake							
Goose Lake, Man.	22.91	1.25	82	54°31'	101°30'	306	1950
Minago River, Man.	23.32	0.94	83	54°10'	99°10'	245	1900
Lake St. George, Man.	24.16	1.06	86	51°43'	96°25'	245	2400
Sandy River, Man.	24.97	1.24	89	50°59'	96°13'	245	2550
Gold Creek, Man.	22.17	1.30	79	51°04'	95°47'	306	1550
Dome Twp. Ont.	23.16	1.63	83	51°06'	93°46'	397	2400
Red Lake, Ont.	24.76	1.05	88	51°02'	93°48'	369	2400
Pickle Lake, Ont.	25.27	1.12	90	51°12'	90°12'	369	1800
Birch Lake, Ont.	25.19	1.45	90	51°24'	92°21'	397	2000
Stranger Lake, Ont.	24.68	1.15	88	50°15'	91°31'	382	2150
Fort Frances/Kenora							
West Hawk Lake, Man.	28.14	1.50	100	49°47'	95°15'	336	2700
East Braintree, Man.	28.49	1.34	102	49°42'	95°35'	336	2800
Mid Interlake, Man.	28.89	1.20	103	52°12'	98°47'	275	2400
Dawson Bay, Man.	28.82	0.88	103	52°58'	101°03'	275	2250
Bernic Lake, Man.	31.75	1.78	113	50°25'	95°36'	275	2600
Whitedog Falls, Ont.	30.16	1.78	107	50°07'	94°52'	352	2650
Kenora, Ont.	25.74	1.68	92	49°45'	94°36'	367	2650
Rainy River, Ont.	31.80	0.92	113	48°44'	94°32'	314	2800
Menary Twp., Ont.	31.20	1.00	111	48°57'	93°56'	367	2750
Sioux Narrows, Ont.	30.71	1.42	109	49°30'	94°04'	336	2700
Flanders, Ont.	30.13	1.75	107	48°44'	92°08'	382	2500
Rainy Lake, Ont.	29.21	1.08	104	48°42'	93°03'	336	2600
S. Manitoba							
Porcupine Mt., Man.	20.94	1.28	75	52°20'	101°32'	611	2300
Nor. West Duck Lake, Man.	23.76	0.96	85	51°45'	101°12'	673	2400
Game Line, Man.	24.15	1.00	86	51°38'	100°42'	673	2400
Angle Inlet, Man.	26.35	1.53	94	49°19'	95°20'	336	2850
Dryden							
Eagle River, Ont.	27.87	2.06	99L	49°49'	93°02'	397	2550
Dinowic, Ont.	28.26	1.35	101L	49°42'	93°30'	397	2500
Needle Lake, Ont.	26.63	1.24	95	49°57'	92°31'	397	2400
Camp Robinson, Ont.	26.83	1.46	96	50°10'	93°15'	367	2400
Ignace, Ont.	28.65	1.22	102	49°25'	91°40'	443	2400
Savant Lake, Ont.	28.96	1.08	103	49°50'	91°05'	428	2250
Uchi Lake, Ont.	26.34	1.51	94	50°48'	93°08'	382	2400
Ear Falls, Ont.	28.24	1.81	101	50°40'	93°20'	382	2400
North of Ear Falls, Ont.	27.30	1.77	97	50°42'	93°22'	382	2400
Lac Seul, Ont.	27.66	1.00	99	50°24'	92°08'	367	2300
Sioux Lookout, Ont.	28.70	1.09	102	50°07'	91°50'	382	2300

* Growing Degree Days - Boughner and Kendal 1959.

Appendix 1 (cont'd)

	Height cm	SE	% of Local (L)	Lat.	Long.	Elev. (m)	GDD*
Atikokan/Thunder Bay							
Eva Lake, Ont.	25.89	1.52	92	48°40'	91°25'	428	2450
Spoon Lake, Ont.	25.79	1.22	92	49°00'	91°07'	489	2400
Cecile Lake, Ont.	25.90	1.06	92	49°33'	91°23'	466	2350
Upsala, Ont.	24.95	1.18	89	49°40'	90°31'	489	2300
Shebandowan, Ont.	25.99	1.15	93	48°37'	90°11'	459	2300
Kakabeka Falls, Ont.	25.30	1.48	94	48°30'	89°30'	259	2250
Parks Lake, Ont.	25.31	1.13	90	49°28'	87°34'	459	2000
Chief Bay, Ont.	27.86	1.03	99	49°30'	89°03'	275	2050
Lake Superior							
Pidgeon River, Ont.	24.09	0.99	86	48°01'	89°39'	306	2400
Nipigon, Ont.	23.46	1.01	84	49°12'	88°13'	229	2050
White River, Ont.	23.40	1.26	83	48°47'	85°30'	459	2000
Wawa, Ont.	22.42	1.13	80	47°55'	84°45'	306	2050
Searchmont, Ont.	24.99	1.01	89	46°44'	83°53'	367	2400
Sault Ste. Marie, Ont.	23.95	1.06	85	46°35'	84°18'	306	2550
Eastern Ontario							
Gore Bay, Ont.	26.23	1.52	93	45°53'	82°19'	229	2800
Nairn, Ont.	25.68	1.66	91	46°20'	81°41'	245	2700
Thessalon, Ont.	26.59	1.11	95	46°18'	83°33'	306	2750
Gurd Twp., Ont.	27.33	1.22	97	45°59'	79°27'	336	2800
French Twp., Ont.	29.60	1.75	105	46°27'	79°10'	306	2750
Jocko River, Ont.	26.29	1.56	94	46°36'	79°10'	306	2700
Calvin Twp., Ont.	29.65	1.05	106	46°17'	79°51'	229	2800
Estaire, Ont.	27.66	1.01	99	46°14'	80°43'	214	2800
Bracebridge, Ont.	25.38	1.37	90	45°07'	79°18'	306	3000
Petawawa N.F.I., Ont.	27.51	1.28	98	46°00'	77°26'	160	2900
Beachburg, Ont.	31.94	1.44	114	45°44'	76°51'	153	3050
Lac Dumoine, Que.	25.20	1.58	90	46°48'	77°48'	290	2900
St. Joseph's Island, Ont.	29.40	0.89	105	46°13'	83°53'	275	2800
Marten River, Ont.	22.46	1.00	80	46°42'	79°48'	275	2700
Aubrey Falls, Ont.	27.26	1.03	97	46°48'	83°12'	352	2450
Reeves Twp., Ont.	26.12	1.06	93	48°13'	82°06'	420	2200
Cobalt, Ont.	26.45	1.82	94	47°20'	79°41'	306	2450
Burt Twp., Ont.	27.38	0.80	98	48°01'	80°20'	306	2300
Clute Twp., Ont.	28.06	1.49	100	49°05'	81°15'	290	2150
New Liskeard, Ont.	27.03	1.60	96	47°30'	79°41'	306	2400
Ashley Mines, Ont.	26.22	1.58	93	48°00'	81°00'	321	2250
Winchester, Ont.	25.15	0.62	90	45°06'	75°18'	76	3400
Peterborough, Ont.	29.03	1.53	103	44°08'	78°18'	229	3500
Birch Island, B.C.	34.43	1.25	123	51°37'	119°50'	428	2100